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Feasibility Report for Water Systems in the South Nablus Area
Final Report

by

EHP Staff

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FEASIBILITY REPORT FOR WATER SYSTEMS IN THE SOUTH NABLUS AREA

Final Report

10 February 2002

Prepared for the USAID Mission for the West Bank and Gaza
Under Task Order HRN-I-802-99-00011-00

EXECUTIVE SUMMARY

PURPOSE AND BACKGROUND

The purpose of this report is to define the basic water system design conditions and water use requirements in the South and South East Nablus villages, as necessary to proceed with design of transmission and distribution system improvements based on the immediate and long term needs of villages in the region during the twenty-year design period extending to 2023.

The South and South East Nablus villages, like many areas of the West Bank, suffer from a severe shortage of drinking water. As part of the United States' participation in the Israeli-Palestinian peace agreement of 1993, the United States Agency for International Development (USAID) is focusing on this and other West Bank areas for providing financial and technical assistance. The goal of this assistance is to provide greater access to and more effective use of extremely limited water resources in the West Bank. In an attempt to tackle the need for environmental improvements in 46 West Bank villages (18 in Nablus area and 28 in Hebron area) USAID conceived of a Village Water and Sanitation (VWS) Program. This report is written as one of the deliverables of the VWS program under Task Order HRN-I-802-99-00011-00.

EXISTING CONDITIONS

There are currently no fixed water supply systems or distribution networks for any of the 18 villages, except in Rujeib, which is served by the Israeli company, Mekorot. Villages must rely on rainwater harvesting, springs and tankered water (water pumped from animal-drawn or trucked tanks) of questionable quality.

DESIGN CRITERIA AND WATER RESOURCES

Design for water demand for the 20-year design period, as requested by PWA, was based on 150 l/c/d, including leakage. Population estimates were based a population growth rate of 4.56% in 1997 extrapolated to 2.26% in 2020 and beyond. With these criteria, the water needs for 2003 population would be 7,987 m^3/day. This water need will be initially partially, satisfied with the well to be drilled near Rujeib in the beginning of 2002. The expected yield of the well is about 5,000 m^3/day. Other sources will have to be identified to satisfy expected demand in the future. Finally, the implications of designing to a lower population growth rate must also be investigated during the design phase, in consultation with PWA.

DESIGN ALTERNATIVES AND OPTIONS

Design alternatives for water supply systems for the South and South East Nablus service area are limited by the location of the anticipated Rujeib well, by routes of existing road systems to serve as rights-of-way, and by locations of demand centers.

Three alternative transmission supply routes were considered in the feasibility study, with a total 20-year storage requirement of about 14,714 m^3. Sizing of concrete lined steel pipes and balancing and storage reservoirs were based on 2023 peak day flows to eliminate the need for subsequent pipe replacement during the 20-year design period. Booster pump stations were kept to a minimum.

Based on the analysis of the required distribution piping for each village during the design period, a total of 251km of distribution piping will have to be installed, with 50% of this consisting of small diameter 25mm HDPE pipe supplying individual homes or multiple home service connections. In addition to distribution piping, internal transmission lines must be installed, connecting village and regional reservoirs to the individual village distribution networks. Regularly spaced air release valves and washouts must be included, as well as pressure reducing valves to maintain the numerous pressure zones in the rugged terrain of the West Bank.

CAPITAL COST ESTIMATE OF THE CHOSEN ALTERNATIVE

Capital costs for transmission lines and distribution system components were developed based upon previous pipeline projects in the West Bank, and on material costs provided by manufacturers. All costs are in year 2001 U.S. dollars and include 15 percent for contractor general conditions, overhead and profit. Pressure reducing valves, air release valves, and clean-outs were assumed to constitute an additional 15 percent, beyond the cost of the distributions system piping. Costs for storage, pumping, and disinfection facilities were based on unit costs and cost formulas derived from previous projects in the West Bank and from information provided by product manufacturers and vendors. All costs are assumed to include contractor general conditions, overhead, and profit.

The capital costs for the chosen alternative, along with an estimated cost for level-of-service options for all villages, Burin Cluster only, Aqraba Cluster only, is given in the Table below (note that Rujeib and Awarta would be served in all options):

CAPITAL COSTS FOR LEVEL OF SERVICE OPTIONS

	Option 1 (All Villages)	**Option 2 (Burin Cluster)**	**Option 3 (Aqraba Cluster)**
Well Development	575,000	575,000	575,000
Disinfection	120,000	120,000	120,000
Transmission Pipelines	8,179,000	3,849,000	5,570,000
Booster Pump Stations	582,000	237,000	582,000
Village Distribution Systems			
Reservoirs	2,790,000	1,470,000	2,100,000
Distribution network	9,600,000	5,190,000	6,100,000
Subtotal	12,390,000	6,660,000	8,200,000
Subtotal	21,846,000	11,441,000	15,047,000
Contingency (20%)	4,369,200	2,288,200	3,009,400
Total Capital Cost	**$26,215,200**	**$13,729,200**	**$18,056,400**

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ABBREVIATIONS

ARV	Air Release Valve
CDM	Camp, Dresser and McKee International, Inc.
EAB	Eastern Aquifer Basin
EHP	Environmental Health Project
HDPE	High Density Polyethylene
JWC	Joint Water Council
Kg/d	Kilograms per day
l/c/d	Liters per Capita per Day
Lpd	Liters per day
m^3	Cubic meter
MBGL	Meters Below Ground Level
N/A	Not available
O&M	Operation and Maintenance
PCBS	Palestinian Central Bureau of Statistics
PMC	Percent Modern Carbon
Ppm	Parts per million
PRV	Pressure Reducing Valve
PWA	Palestinian Water Authority
USAID	United States Agency for International Development
WAB	Western Aquifer Basin
WRP	Water Resources Program

1 INTRODUCTION

1.1 BACKGROUND

The South Nablus area, like many areas of the West Bank, suffers from a severe shortage of drinking water. As part of the United States' participation in the Israeli-Palestinian peace agreement of 1993, the United States Agency for International Development (USAID) is focusing on this and other West Bank areas for providing financial and technical assistance. The goal of this assistance is to provide greater access to and more effective use of extremely limited water resources in the West Bank

1.2 PURPOSE OF THE STUDY

The purpose of this report is to define the basic water system design conditions and water use requirements in the South Nablus areas, as necessary to proceed with design of transmission and distribution system improvements based on the immediate and long term needs of villages in the region during the twenty-year design period extending to 2023. Eighteen villages in the area south of Nablus were included in this analysis, as shown on **Figure 1-1**. These villages include eight in the vicinity of Burin and ten near the town of Aqraba, as listed in **Table 1-1**. It should be noted that Rujeib village has been included in this analysis because of its proximity to the well source and in order to redirect the existing Mekerot supply for other uses.

1.3 APPROACH

The approach used in this Feasibility Study included the following key steps:

1) **Examination of Existing Conditions.** As part of the Feasibility Study, information about the existing water sources, water supply, transmission and distribution, historical water usage, and storage facilities was collected and evaluated for all villages in the study area.

2) **Development of Design Criteria.** This report details the design criteria and assumptions used in the preliminary design analysis to establish water demands, flow variations, and peak factors, as well as assumptions for storage requirements, balancing, and pumping requirements, and distribution networks for the 18 villages in the study area.

3) **Assessment of Future Water Requirements.** The design criteria developed in the previous step, including current population figures, growth rates, per capita consumption rates, etc., were used to establish future (Year 2023) water supply, transmission, distribution, and storage requirements.

4) **Development of Design Alternatives and Options.** The Report includes preliminary calculations of sizes and quantities for each of three alternatives based on the proposed design criteria developed in Step 2. Three alternative pipe routes are examined, with related pumping and storage options. The Report also presents a preliminary estimate of construction costs for each alternative based on the assumptions described in the Report.

5) **Comparison of Design Alternatives and Options and Recommendation of Best Design Approach.** The report documents the comparative analysis performed for each of the design alternatives and options. The basic criteria used in this analysis included cost (capital and operating), constructability, operation and maintenance, and site-specific requirements.

Based on the results of this comparative analysis, the best overall design approach was selected. The outline for this report follows the basic flow of the steps for the approach described above. Whichever design alternative is chosen, there are certain political implications that must be considered. These would include the problem of obtaining permits or approvals from the Joint Water Council (JWC) and other agencies for pipeline routes, reservoir sitting, location of pumping stations, etc. However, it is considered that whichever alternative is finally chosen, these problems would be similar.

Figure 1-1 – South Nablus Villages Location Map

Table 1-1
South Nablus Villages Included in Study

Village English Name	Village Arabic Name	Locality Code from the PCBS
Burin Cluster	**مجموعة بورين**	
Asira Al Qibliya	عصيرة القبلية	151095
Burin	بورين	151080
Einabus	عينبوس	151195
Madama	مادما	151050
Rujeib	روجيب	151010
Sarra	صرة	150955
Tell	تل	150990
Urif	عوريف	151160
Aqraba Cluster	**مجموعة عقربا**	
Aqraba	عقربا	151270
Awarta	عورتا	151135
Duma	دوما	151445
Jalud	جالود	151420
Jurish	جوريش	151345
Majdal Bani Fadel	مجدل بني فاضل	151385
Osarin	أوصرين	151265
Qaryut	قريوت	151410
Qusra	قصرة	151365
Talfit	تلفيت	151375

2 EXISTING CONDITIONS

2.1 EXISTING WATER RESOURCES

In general, the water supply situation in most of the villages is poor. There are three existing water supply sources available to the study area villages: 1) rain water, 2) water collected from local springs, and 3) tankered supplies (water carried by animal-drawn or trucked tanks from nearby settlements and Mekorot wells). The only village that has some piped supply is Rujeib, which gets Mekerot water.

A design for distribution system improvements was completed in 1999 for seven of the villages within the Aqraba cluster, with the intention of making use of a well, planned north of Aqraba, as the source of supply. Although the intended source of supply for these villages has changed, as has the number of villages to be served, any future design for these seven villages will need to include an evaluation of this existing design to determine its applicability under the current design conditions.

2.1.1 Household Rainwater Collection

Individual households in the South Nablus area collect rainwater from the roofs. It is drained via down-pipes to underground cisterns, typically holding up to 50 cubic meters (m^3) of water. Water is then pumped from the cisterns to smaller rooftop storage tanks on an as-needed basis. Dewatering and physical examination of cisterns was not performed as part of this feasibility study, however, it is likely that many are not watertight and are not maintained under sanitary conditions. Leaking cisterns can pose a serious health risk as water stored in this manner can become subject to the inflow of groundwater contaminated by seepage from seldom-emptied cesspits and septic tanks.

Further complicating this type of water supply is the fact that rainwater stocks are normally depleted by August of each year. It is usually not until December that supplies begin again to replenish themselves.

2.1.2 Local Springs

A number of springs have been developed for drinking water use in the villages. The level of wellhead protection and overall sanitary practices around the springs vary from village to village and spring to spring. Many of the springs have tested positive for fecal coliform or other contamination, due to direct influence from nearby cesspits and garbage piles. Capacities for the springs are low, with flows decreasing significantly during the dry season when the water supply is most critical. Some of the springs have been piped to community taps where individual residents fill daily water jugs. Other springs feed storage reservoirs, which are used to fill tractor pulled tankers delivering to individual homes. Due to the low, unreliable capacities and questionable water quality of these springs, they were not considered an acceptable source for continued drinking water usage in the study villages.

2.1.3 Delivery Tankers (Tankered Water)

During the portion of the year when sufficient water cannot be obtained from rainwater collection, tanker trucks delivering to the individual household cisterns provide an alternate water supply. Tanker trucks are generally filled outside nearby Israeli settlements or at wells owned by the Israeli water company, Mekorot, where water is available. Palestinian homes typically pay between $20 and $40 (USD) for 10 cubic meters of water. Because of the high costs, potential health risk, unreliable water supply and difficulty involved with obtaining water through tanker truck delivery, it is not considered an acceptable long term supply alternative for the South Nablus villages.

2.2 EXISTING STORAGE AND DISTRIBUTION SYSTEMS

There are currently no fixed water supply systems or distribution networks for any of the 18 villages, except in Rujeib which is served by Mekorot.

3 DESIGN CRITERIA

This section presents the design criteria and assumptions used in the feasibility study to establish water demands, flow variations, pumping rates, power efficiencies, water quality, and certain hydraulic standards. These criteria were then used in determining design requirements for pumping, storage, and balancing, which formed the basis for the development and comparison of alternatives and options in the South Nablus service areas transmission, storage, and distribution systems.

3.1 WATER DEMANDS

Total water demand is a function of multiple variables and includes domestic, government, institutional, industrial, and leakage components. Irrigation water demand is not considered as part of the domestic demand. Population changes must also be considered. The various criteria and assumptions used in the feasibility study to determine total water demand are listed below:

1) **Existing Population.** 1997 population estimates for the South Nablus area villages were obtained from the Palestinian Central Bureau of Statistics (PCBS). The methodology used by the PCBS to determine current populations is sound and the published figures are assumed to be correct.

2) **Population Growth Rates.** Population growth rates are assumed to vary during the design period from 4.56 per annum in 1997 to 2.26 in 2020 and beyond, as established by the PCBS. This assumption will be reassessed in consultation with PWA, during the design phase.

3) **Domestic Consumption.** Domestic consumption was initially estimated based on the criteria established in the September 2000 *Planning and Design Guidelines* published by the Palestinian Water Authority (PWA). Domestic demands, by this standard, would increase steadily during the 20-year design period from 137 liters per capita per day (l/c/d) to 180 l/c/d. During a meeting with the PWA on November 7, 2001, direction was given to limit the design criteria for domestic demand to 150 l/c/d during the entire design period. It was also directed that this demand would encompass other types of water use, including governmental, institutional, industrial, commercial, and unaccounted for water.

4) **Unbilled Consumption.** Unbilled consumption is included with the estimate for domestic consumption.

5) **Leakage.** Leakage is a function of pressure, pipe lengths, pipe age and the number of service connections and is based on demand. Leakage was initially estimated at 20 percent of average domestic demand, based on the newness of the distribution system. Based on direction given at the November 7, 2001 meeting with the PWA, leakage has been included in the 150 l/c/d domestic demand estimate.

6) **Public Use: Government and Institutional Demand.** Governmental and institutional demands, currently consisting primarily of schools in the South Nablus villages, were initially assumed to increase steadily from 7.2 l/c/d to 11.9 l/c/d during the 20-year design period, based upon the numbers used in the September 2000 *Feasibility Study and Preliminary Design of Bulk Water Supply and Village Water Distribution Systems in Hebron, Bethlehem and Nablus Districts*. Based upon the November 7, 2001 meeting with the PWA, public use has been included in the 150 l/c/d domestic demand estimate.

7) **Industrial and Commercial Demand.** Commercial and industrial water demands in the villages are relatively small, particularly in the smaller villages to the south. Water-dependent industrial demands, particularly the light industries are expected to increase once both the supply and distribution schemes in the villages have been completed and confidence in the reliability of the water supply has been established. The combined industrial and commercial water demand was initially assumed to increase steadily during the 20-year design period from 7.2 l/c/d to 19.6 l/c/d, based upon the numbers used in the previously referenced September 2000 *Feasibility Study and Preliminary Design Report*. Based upon the November 7, 2001 meeting with the PWA, industrial and commercial demand have been included in the 150 l/c/d domestic demand estimate.

8) **Animal and Livestock Demands.** It is anticipated that animal and residential livestock will be provided water from existing springs, shallow wells, and other non-domestic water sources throughout the design horizon. Animal and residential livestock were therefore not considered to impact the calculation of total residential water demand.

9) **Agricultural Demands.** Similar to the animal and livestock demand, it is anticipated that agricultural water demand will continue to be met from the existing agricultural wells and/or springs through the design horizon and, therefore, do not figure into the calculation of total water demand.

3.2 DEMAND FLOW VARIATIONS

Water consumption and demand fluctuate regularly depending on the time of day and time of year. To reflect these periodic fluctuations from the average daily demand, peaking factors were developed based upon guidelines set by the September 2000 PWA *Planning and Design Guidelines* and the March 1997 *Water Supply Facility Master Plan*. These peaking factors include:

1) **Peak Day Flow.** Peak day flow is assumed to be 1.44 x the average day demand.

2) **Peak Hour Flow.** Peak hour flow is assumed to be 1.5 x the Peak Day Flow.

3.3 TRANSMISSION AND STORAGE DESIGN CRITERIA

Additional design criteria, involving transmission and storage requirements, include:

1) **Pumping Rates.** The design pumping rate is assumed to be 1.1 x the peak day flow.

2) **Balancing Storage.** The design balancing storage is assumed to be four hours at the design pumping rates.

3) **Supply Storage.** The design storage is 24 hours at the average daily demand.

4) **Hydraulic Criteria.** Friction losses in the pumping mains are calculated using the Hazen-Williams formula, using a roughness value C of 130 for concrete lined steel pipes.

5) **Level Data.** The levels taken from the 1:50,000 scale Topographical Survey maps are assumed to have a level of accuracy within 10 meters.

6) **Power Requirements.** Well pumps and booster pumps are assumed to have an efficiency of 75 percent, including driver losses.

3.4 ALLOWABLE PRESSURES

Pressures within the distribution system must remain below the allowable limit for the piping and must be above the lowest recommended level for residential service connections. The September 2000 *Planning and Design Guidelines* established by the PWA set the minimum residential pressure at 20 meters of water. Maximum pressures within the distribution piping should not exceed 100 meters, assuming 16 bar HDPE piping will be used, and should not exceed 60 meters at service connections, based upon PWA guidelines. [Note that other pipe materials will be reviewed during design, in consultation with PWA.]

Pressures within the transmission lines must remain below the allowable limit for concrete lined steel pipes, based on the recommendations of local pipe manufacturers. Maximum allowable pressures range from 24 bars in 450 mm (18-inch) pipe to 44 bars in pipes 200 mm (8-inch) and smaller.

4 WATER RESOURCE AND STORAGE NEEDS

4.1 WATER DEMAND CALCULATIONS

The most recent population estimates for the South Nablus villages (1997), determined by the Palestinian Central Bureau Of Statistics (PCBS), in their publication *Small Area Population, 1997-2010*, were used as the basis of the population estimates for this preliminary design. These population estimates were multiplied by annual population growth estimates, as published by the PCBS, which ranged from 4.56% in 1997 to 2.26% in 2020 and beyond. Annual population growth estimates used in this study are shown in **Table 4-1**. Expected average daily water demands for each village were calculated using the expected daily demand of 150 liters per person during the 20-year design period. A sample calculation illustrating the method used to determine population and demand is provided below.

<u>Sample Water Demand Calculation</u>

Sarra 1997 Population: 2,133

Annual Growth Rate (1997-2000): 4.56%
Annual Growth Rate (2001): 4.50%
Annual Growth Rate (2002): 4.43%

Initial Design Horizon (Year): 2003

Total Growth: $(1.0456)^{(2000-1997)}$ (1.0450) (1.0443) = 1.304

Initial Design Population: 2,133 x 1.304 = 2,782

Sarra Initial Demand: 2,782 x 0.150 m^3/c/d **= 417 m^3/d**

Population figures for 1997, 2003, and 2023, together with the computed average daily water demands for each of the 18 villages are summarized in Table 4-1. Again, note that the growth rate assumptions will be reassessed in consultation with PWA, during the design phase.

4.2 DESIGN WATER RESOURCE NEEDS

The additional amount of water needed to meet initial design conditions would typically be determined as the difference between the current supply capacity and the future demand requirements. However, the existing sources of water for the 18 villages are not considered to be suitable long-term or reliable sources of water for domestic consumption. The increased water resources required for the initial design horizon was therefore calculated as 7,987 m^3/day, which is the total calculated demand for the year 2003 (the beginning of the design period).

It should be noted that water supply requirements were based on initial water needs at the beginning of the design period, however, planning and alternatives evaluation should continue to be pursued in order to meet projected demands through the entire 20 year design period. In addition, anticipated production from the planned Rujeib well does not exceed 5,000 m^3/day, which is not sufficient to meet the design criteria requirements, even for the immediate term. For this reason, it will be necessary to either limit consumption below the levels defined in this study or to make additional water supplies available before the beginning of the design period. This issue is discussed in depth within Section 6 of this report.

TABLE 4-1
POPULATIONS AND DESIGN WATER DEMANDS

SOUTH NABLUS VILLAGES				PROJECTED WATER DEMANDS	
Village	**Population**			**Total Flow**	
	1997	**2003**	**2023**	**2003 (m^3/day)**	**2023* (m^3/day)**
Burin Cluster					
Asira Al-Qiblyia	1,686	2,199	4,051	330	608
Burin	2,424	3,162	5,824	474	874
Einabus	1,637	2,135	3,933	320	590
Madama	1,223	1,595	2,939	239	441
Rujeib	2,888	3,767	6,939	565	1,041
Sarra	2,133	2,782	5,125	417	769
Tell	3,496	4,560	8,400	684	1,260
Urif	2,094	2,731	5,032	410	755
Total		**22,932**	**42,244**	**3,440**	**6,337**
Aqraba Cluster					
Aqraba	5,849	7,629	14,054	1,144	2,108
Awarta	4,286	5,590	10,299	839	1,545
Duma	1,637	2,135	3,933	320	590
Jalud	334	436	803	65	120
Jurish	1,020	1,330	2,451	200	368
Majdal Bani Fadel	1,611	2,101	3,871	315	581
Osarin	1,202	1,568	2,888	235	433
Qaryut	1,821	2,375	4,376	356	656
Qusra	3,276	4,273	7,872	641	1,181
Talfit	2,206	2,877	5,301	432	795
Total		**30,316**	**55,847**	**4,547**	**8,377**
Total South Nablus		**53,248**	**98,091**	**7,987**	**14,714**

* *Note: These numbers also represent the daily storage needs in 2023 in cubic meters. A total of 8,377 m^3 of storage will be required.*

4.3 DESIGN STORAGE NEEDS

As previously discussed, there is no suitable existing storage available for water in any of the villages in the study area. Total storage requirements were therefore calculated as the volume required for 24 hours demand at average daily flow for each village or service area. The storage requirements for each village are shown in **Table 4-1** as described in the footnote. It should be noted that storage tanks need not be added in each individual village, as many of the villages can be combined into joint service areas due to their geographic proximity and similarity in elevations. Such an approach will provide significant savings in construction costs and operational complexity. The use of redundant or semi-redundant storage facilities is typically recommended to allow for tank maintenance and periodic cleaning and disinfection, however, this type of redundancy can most easily be provided by installing a central wall in each of the reservoirs allowing either side to be drained down and maintained while the other half remains in service.

Household storage using rainwater cisterns and roof tanks are subject to contamination as discussed in Section 2. As population density increases, fewer villagers will have space for the large underground cisterns. Therefore, the design conditions described here are based on a constant available flow, excluding household storage capacity. However, in reality, villagers will likely continue to use household storage to hedge against uncertain supply and to exploit the free rainwater source. Public health education on this issue will be integrated into concurrent VWS institutional programs.

4.4 DISTRIBUTION NETWORK REQUIREMENTS

A conceptual level estimate of the required size and lengths of distribution network piping was made based on the design populations for each village. Specifically, it was assumed that the total length of pipe to be installed will be a function of the population at the beginning of the design period, while the diameter of the piping will be a function of the population at the end of the 20 year design period. This assumption accounts for the recommendation that no pipes be installed for houses which have not yet been constructed, but that all piping in the new systems be sized for flows necessary to supply all of the future water demands within the design period.

To determine the general relationship between service area population and distribution system characteristics, recent designs were analyzed for 18 West Bank village distribution systems including previous designs for seven villages in the Aqraba cluster, as well as eleven villages in the Jenin area. The results of this analysis indicated a median correlation of 4.7 meters of pipe per person served. This correlation is presented graphically in **Figure 4-1**. The size of distribution piping was also characterized for the 18 villages, with the results summarized in **Table 4-2**. These correlations are used in Section 5 to determine sizes and lengths of distribution system piping in the 18 south Nablus villages.

Table 4-2
Size of Distribution System Piping in Aqraba and Jenin Area Village Designs

Population	Percent of Distribution Piping in Size Category						
	25 mm	50 mm	100 mm	150 mm	200 mm	250 mm	300 mm
Less than 2,000	50	20	20	5	5	0	0
2,000 to 5,000	50	20	20	5	3	2	0
Greater than 5,000	50	18	20	3	4	3	2

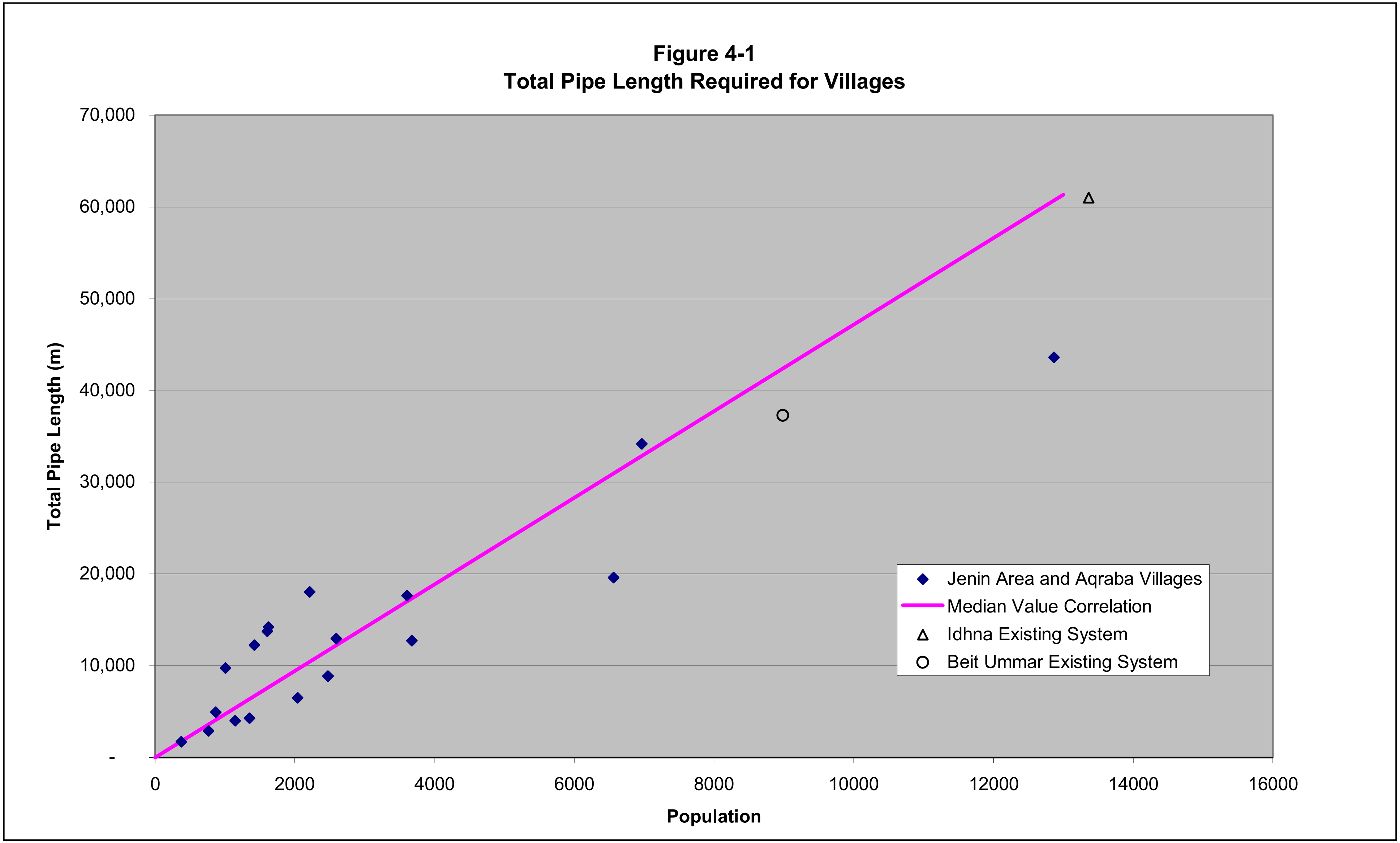
Figure 4-1
Total Pipe Length Required for Villages
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Total Pipe Length (m)
0
2000
4000
6000
8000
10000
12000
14000
16000
Population
Jenin Area and Aqraba Villages
Median Value Correlation
Idhna Existing System
Beit Ummar Existing System

4.5 WATER QUALITY REQUIREMENTS

Water quality in the distribution system is a function of the initial water quality from the well and on any potential degradation of water quality within the transmission and distribution lines or storage facilities. The primary concern from a water quality perspective, is the risk of biological contamination, extended water age, and the potential loss of chlorine residual in the transmission lines and storage. Biological contamination can be introduced through any one of the following mechanisms:

- Storage reservoirs not maintained under sanitary conditions
- New piping, valves, or storage tanks added to system without proper cleaning and disinfection
- Introduction of contaminated water from third party storage facilities, such as underground storage tanks, or backflow from contaminated water services
- Leaks in transmission or distribution piping within contaminated areas
- Growth of bacterial or algal colonies within piping networks or storage tanks
- Household water management practices can introduce additional similar risks

For this reason it is essential that a detectable chlorine or chloramine residual be maintained within all of the distribution systems at all times. Chlorination and/or chloramination is generally carried out at the point of entry for the transmission system, which could be at either the well sites, the regional reservoirs, or at multiple locations. The use of chloramines provides for extended longevity of residual chlorine, and generally has a less noticeable impact on the taste of the water.

5 DESIGN ALTERNATIVES AND OPTIONS

5.1 INTRODUCTION

Design alternatives for water supply systems for the South Nablus service area are limited by the location of the anticipated Rujeib well, by routes of existing road systems to serve as rights-of-way, and by locations of demand centers.

Three alternative transmission supply routes were considered in the feasibility study. Each of the alternatives is described in detail in this section. In addition, three level-of-service options are presented in Section 7 to serve either all of the 18 villages, or to serve either of the two clusters. Hydraulic and water quality modeling for each of the design alternatives were evaluated using H2Onet version 3.1 modeling software.

5.2 SOURCE OF SUPPLY

The proposed Rujeib well is located approximately 1.5 km southwest of Rujeib along Nablus-Ramallah road. At the time of this writing, this well had not yet been tested nor had any boreholes been drilled, however, capacity has been estimated with a reasonable degree of reliability based on nearby wells drawing from the same water source. Ground level at the site is approximately 500 m above the ordnance datum. The yield of the proposed well is estimated as approximately 250 m^3/hour or about 5,000m^3/day.

5.3 ALTERNATIVE TRANSMISSION ROUTES AND STORAGE

Three pipe routing alternatives were considered for transmission from the Rujeib well. Each of these routes was examined under three design conditions, including 2023 peak day flow, 2003 peak day flow, and 2003 available supply. Sizing of pipes and reservoirs was based on the 2023 peak day flow to eliminate the need for subsequent pipe replacement during the 20-year design period. Pipe routes are shown on the maps in **Figures 5-1** to **5-3**. The estimated lengths of the transmission pipelines for the three alternatives are presented in **Table 5-1**. General descriptions of the pipe routes are given below, with a more thorough description included as **Annex A**.

5.3.1 Alternative 1

Using this routing scenario all of the villages would be served through a pump station and balancing reservoir at the Rujeib well site. The village of Rujeib would be supplied by a dedicated pipeline from the well site to the Rujeib village reservoir. Villages in the Burin cluster would be supplied via a branch to regional reservoirs at Burin and Tell. The Burin reservoir then has two outflow lines, the first serving Burin, and the second serving Madama, Asira al-Qibliya, Urif and Einabus. The second main branch from the Rujeib well pump station feeds Awarta as an off-take to its local reservoir and continues to the Aqraba area booster pump station and balancing reservoir, located east of Aqraba.

The Aqraba area booster pump station supplies water to three regional reservoirs. The Aqraba village reservoir serves the villages of Aqraba and Osarin. A regional reservoir outside Majdal Bani Fadel serves both Majdal Bani Fadel and Duma; and finally, a regional reservoir in Qusra serves the villages of Qusra, Jurish, Jalud, Qaryut and Talfit.

Locations of the assumed reservoirs for Alternative 1, along with the estimated populations served and storage volumes, are given in **Table 5-2**.

Figure 5-1 Map of pipe routes for Alternative 1

Figure 5-2 Map of pipe routes for Alternative 2

Figure 5-3 Map of pipe routes for Alternative 3

5.3.2 Alternative 2

Similar to Alternative 1, all villages would be served through a pump station and balancing reservoir at the Rujeib well site. Service to the village of Rujeib would be identical to Alternative 1. Service to villages in the Burin cluster would be similar to that of Alternative 1 except that Einabus would be supplied by a dedicated off-take to its local reservoir from the trunk main feeding the Aqraba cluster. Awarta would also be supplied by another off-take to its local reservoir from the trunk main feeding the Aqraba cluster.

Serving the Aqraba cluster, the Aqraba area booster pump station and balancing reservoir would be located west of Osarin. This booster pump station would serve local reservoirs in Osarin and Aqraba, as well as the regional reservoirs near Majdal Bani Fadil and Qusra, as described in Alternative 1. Information on assumed reservoirs for Alternative 2 is given in Table 5-2.

5.3.3 Alternative 3

Using this routing scenario, service to Rujeib and the Burin cluster would be identical to Alternative 1. The village of Awarta would be served via its local reservoir through the main trunk line to the Aqraba area booster pump station and balancing reservoir. The booster pump station, located north of Osarin, would then serve local reservoirs in Osarin and Aqraba, and regional reservoirs in Majdal Bani Fadel and Qusra, similar to Alternative 2. Information on assumed reservoirs for Alternative 3 is given in Table 5-2.

5.4 DISTRIBUTION NETWORKS

Distribution network piping sizes and lengths were calculated for each village, based upon the criteria described in Section 4, and are presented in **Table 5-3**. Calculated pipe lengths include all major and minor trunk lines and standard service connections within the distribution networks. The total length of distribution piping for the 18 villages is estimated at 251 km, with 50 percent of this consisting of small diameter 25 mm HDPE pipe supplying individual homes or multiple home service connections. It was assumed in this analysis that no trunk lines will be smaller than 50 mm diameter, regardless of the size of the village.

Multiple pressure zones must be maintained in each service area through the use of pressure reducing valves (PRVs), air release valves (ARVs), and by gravity feed from the local or regional storage tanks. In addition, each distribution system must include well-distributed washouts at low points in the systems and at dead-ends in the network, as well as periodic isolation gate valves to facilitate service area maintenance.

Table 5-1 Estimated Pipe Length for each Pipe diameter of the Transmission Pipelines for the Three Alternatives (in meters)

Diameter	Alternative 1	Alternative 2	Alternative 3
75		322	268
100	268	1,145	
150	21,762	24,580	23,765
200	4,202	6,604	2,086
250	19,604	15,679	15,334
300	7,371	8,370	7,371
350	4,703	6,139	9,015
400	12,004	11,640	6,918
450	2,089	3,154	2,089
Total	**72,003**	**77,633**	**66,846**

TABLE 5-2
SIZE AND LOCATIONS OF STORAGE RESERVOIRS

Location	Base Elevation (m)	Capacity (m^3)	Villages Served	2003 Population Served	2023 Population Served
Alternative 1					
Rujeib Well	500	2,000	Balancing Only	--	--
Aqraba Pump Station	670	1,300	Balancing Only	--	--
Aqraba Reservoir	810	2,500	Aqraba, Osarin	9,197	16,942
Awarta Reservoir	670	1,500	Awarta	5,590	10,299
Burin Reservoir	670	3,000	Burin, Madama, Asira Al-Qibliya, Urif, Einabus	11,823	21,779
Majdal Bani Fadil Reservoir	699	1,200	Majdal Bani Fadil, Duma	4,237	7,804
Osarin Reservoir	840	3,000	Qusra, Jalud, Qaryut, Talfit,Jurish	11,292	20,801
Qusra Reservoir	600	1,000	Rujeib	3,767	6,939
Rujeib Reservoir	670	2,000	Tell, Sarra	7,342	13,526
Total Alternative 1		**17,500**		**53,248**	**98,091**
Alternative 2					
Rujeib Well	500	2,000	Balancing Only	--	--
Aqraba Pump Station	670	1,300	Balancing Only	--	--
Aqraba Reservoir	810	2,000	Aqraba	7,629	14,054
Awarta Reservoir	670	1,600	Awarta	5,590	10,299
Burin Reservoir	670	3,000	Burin, Madama, Asira Al-Qibliya, Urif	9,687	17,846
Majdal Bani Fadil Reservoir	535	600	Einabus	2,135	3,933
Osarin Reservoir	699	1,200	Majdal Bani Fadil, Duma	4,237	7,804
Qusra Reservoir	720	500	Osarin	1,568	2,888
Rujeib Reservoir	840	3,000	Qusra, Jalud, Qaryut, Talfit,Jurish	11,292	20,801
Tell Reservoir	600	1,000	Rujeib	3,767	6,939
Rujeib Well	670	2,000	Tell, Sarra	7,342	13,526
Total Alternative 2		**18,200**		**53,248**	**98,091**
Alternative 3					
Rujeib Well	500	2,000	Balancing Only	--	--
Aqraba Pump Station	670	1,300	Balancing Only	--	--
Aqraba Reservoir	810	2,000	Aqraba	7,629	14,054
Awarta Reservoir	670	1,600	Awarta	5,590	10,299
Burin Reservoir	670	3,000	Burin, Madama, Asira Al-Qibliya, Urif, Einabus	11,823	21,779
Majdal Bani Fadil Reservoir	699	1,200	Majdal Bani Fadil, Duma	4,237	7,804
Osarin Reservoir	720	500	Osarin	1,568	2,888
Qusra Reservoir	840	3,000	Qusra, Jalud, Qaryut, Talfit,Jurish	11,292	20,801
Rujeib Reservoir	600	1,000	Rujeib	3,767	6,939
Tell Reservoir	670	2,000	Tell, Sarra	7,342	13,526
Total Alternative 3		**17,600**		**53,248**	**98,091**

Table 5-3											
Estimated Distribution System Pipe Lengths for South NablusVillages											
Village	Locality Code	Design Initial Population	Design Ultimate Population	Total Length of Pipe (m) with Diameter:							Total Pipe Length (m)
		2003	2023	25 mm	50 mm	100 mm	150 mm	200 mm	250 mm	300 mm	
Burin Cluster											
Asira Al Qibliya	151095	2,199	4,051	5,190	2,076	2,076	519	311	208	-	10,380
Burin	151080	3,162	5,824	7,462	2,686	2,985	448	597	448	298	14,924
Einabus	151195	2,135	3,933	5,039	2,016	2,016	504	302	202	-	10,078
Madama	151050	1,595	2,939	3,765	1,506	1,506	376	226	151		7,530
Rujeib	151010	3,767	6,939	8,890	3,556	3,556	889	533	356	-	17,780
Sarra	150955	2,782	5,125	6,566	2,364	2,626	394	525	394	263	13,132
Tell	150990	4,560	8,400	10,762	3,874	4,305	646	861	646	430	21,523
Urif	151160	2,731	5,032	6,446	2,321	2,578	387	516	387	258	12,892
Total		22,932	42,244								
Aqraba Cluster											
Aqraba	151270	7,629	14,054	18,005	6,482	7,202	1,080	1,440	1,080	720	36,010
Awarta	151135	5,590	10,299	13,194	4,750	5,277	792	1,055	792	528	26,387
Duma	151445	2,135	3,933	5,039	1,814	2,016	302	403	302	202	10,078
Jalud	151420	436	803	1,028	411	411	103	62	41	-	2,056
Jurish	151345	1,330	2,451	3,140	1,256	1,256	314	314	-	-	6,280
Majdal Bani Fadel	151385	2,101	3,871	4,959	1,984	1,984	496	298	198	-	9,918
Osarin	151265	1,568	2,888	3,700	1,480	1,480	370	222	148	-	7,400
Qaryut	151410	2,375	4,376	5,606	2,242	2,242	561	336	224	-	11,211
Qusra	151365	4,273	7,872	10,085	4,034	4,034	1,008	605	403	-	20,169
Talfit	151375	2,877	5,301	6,791	2,445	2,716	407	543	407	272	13,581
Total		30,316	55,847								
Total South Nablus		**53,248**	**98,091**	**125,665**	**47,296**	**50,266**	**9,596**	**9,151**	**6,386**	**2,971**	**251,331**

5.5 PRELIMINARY DESIGN CALCULATIONS OF ALTERNATIVES

5.5.1 Pumping Rates to Villages

The calculation of the required pumping rates to the villages assumes that flow will be distributed evenly based on population and that the total flow provided will be according to the three design conditions: 2023 peak day flow, 2003 peak day flow, and 2003 available flow. The last of these design conditions is based not on previously specified design criteria, but on the anticipated supply of new water from the Rujeib well (5,000 m^3/day). Issues related to the availability of water are discussed in detail within Section 6. The design pumping rates are shown in **Table 5-4**. As shown, the Aqraba area requires a booster pump station because it is at a higher elevation than the Burin area villages. Therefore, of the 250 m^3/hr coming from the Rujeib well, only 155 m^3/hr well need to be pumped up to the Aqraba cluster villages under 2003 Available Flow conditions. The remaining 95 m^3/hr would flow without re-pumping to the Burin cluster.

TABLE 5-4
DESIGN FLOW RATES FOR PUMPING FACILITIES

Pump Location	Required Flow (m^3/hr)		
	2023 Peak Day	2003 Peak Day	2003 Available
Rujeib Well	*1,280*	*690*	*250*
Aqraba Area	590	320	155*

*Remaining 95 m^3/hr flows without repumping to the Burin cluster.

5.5.2 Flow Rates and Pipe Sizes

Transmission pipes were sized initially for a velocity of 1.5 m/s. A minimum design diameter of 100 mm was assumed and pipes were sized up or down to the nearest commercially available diameter for concrete lined steel pipe. Pipe diameters for each alternative are shown in Figures 5-1 to 5-3.

5.5.3 Preliminary Hydraulic Calculations

Preliminary head loss calculations and design flow rates for each alternative are included in the **Annex B** of this report. The calculations assume a starting pressure of 0 m at the Rujeib well site. Pipe sizes were adjusted to ensure that adequate pressures (as defined previously) would be provided to each village under 2023 peak day flow conditions, and that maximum allowable pressures would not be exceeded under any of the design flow conditions.

5.5.4 Required Pump Capacities

Required pump head and motor capacities were calculated for the 2003 available flow conditions. It is not recommended that pumping capacity be provided for either of the peak day flow conditions, as the water is not yet available to provide these flows. At such a point in the future when new water has been made available, additional pumps will need to be added at the source of the new supply. **Table 5-5** presents the required pump head and power requirements for the 2003 available flow conditions. Power requirements shown in Table 5-5 assume 75% efficiency for the pumps and motors. It is assumed that three pumps will be used at each site, each providing 50% of the required capacity, allowing for any one of the pumps to be out of service for maintenance or repairs without causing disruption in the water supply.

TABLE 5-5
DESIGN PUMPING CAPACITIES

Pump Station Location	Required Flow (m^3/hr)	Minimum Head (m)	Power Required (kW)
Rujeib Well	250	180	167
Aqraba Area	155	180	103

5.6 Water Quality

Water quality was evaluated based on the age of water entering the village distribution networks. Excessive water age allows for degradation of chlorine residual and the potential for biological contamination within the transmission, storage, and distribution networks. Water age was evaluated using H2Onet modeling software, based on 2003 available flow during one month of design flow conditions. These analyses indicated that water age could exceed 200 hours in villages furthest from the Rujeib well site under typical flow conditions.

Due to the high reactivity of free chlorine, it degrades quickly after addition, typically losing half its initial residual concentration within 20-50 hours after chlorination. In contrast, ammoniated chorine, or chloramine, can maintain more than 75% of its initial residual concentration for residence times exceeding 150 hours. This residual persistence makes chloramine particularly attractive for intermittent supplies. An additional benefit of chloramines is that they are generally thought to have a less objectionable, and less noticeable, taste and odor at concentrations exceeding 2 mg/L. For these reasons, and to avoid the use of multiple chlorine injection points that would add to O&M burden and safety concerns, it is recommended that both chlorine and ammonia be employed for disinfection in the South Nablus villages.

6 AVAILABILITY OF WATER FOR NABLUS VILLAGES SERVICE AREA

6.1 Potential Water Sources

As described in Section 4, total water requirements in the Nablus villages service area are estimated to be 7,987 m^3/day in year 2003 and 14,714 m^3/day in year 2023. This section outlines existing water sources in the Nablus area, and provides a summary of potential, total quantities of water that may be accessed from wells and springs to the Nablus villages service area.

For the purposes of this Study, it is assumed that water for the Nablus villages service area will be derived from wells only. While there are numerous springs located in the vicinity of the study area, most springs discharge small quantities of water of variable quality and commonly dry up during the summer months.

The single largest spring in vicinity of Nablus is Ein Beddan at the head of the Fara'a Valley (Wadi Fara'a). The total average discharge of Ein Beddan is about 3,500 m^3/day. The water from the Beddan spring group is heavily utilized for irrigation along Wadi Fara'a, one of the most significant Palestinian agricultural areas in the West Bank.

Under average hydrological conditions, Ein Beddan, along with the Fara'a spring located nearby, provides perennial base flow to Wadi Fara'a. In most years, some excess water drains to the Jordan Valley (DAI, 1999). This excess water could potentially be harvested for domestic use, however, a more detailed water budget and hydrogeological study of the springs should be conducted, which includes more detailed, long-term measurement of spring discharges.

While the hydrogeology and catchment area of Ein Beddan may not be entirely understood, its geological position suggests that it drains water from Eocene formations and, potentially, the Turonian (Upper Cenomanian) aquifer. Historically, Ein Beddan has been a reliable source of water, although this year (2001), a reduction in spring flow has been noted, most probably due to the prolonged drought in the region. Similarly, the nearby Fara'a spring is reported to have dried up this summer (PWA, personal communication).

Any study on potential harvesting of excess base flow from Ein Beddan and nearby springs would also require detailed characterization and analyses of farming, irrigation practices, and water needs for the entire Fara'a Valley, to ensure that harvesting would not interfere with agricultural production.

Even if excess discharges from these large springs could be harvested, and used as a potential supplemental source of water for the Nablus villages service area, the water would likely require expensive pre-treatment, as well as piping, to the service area. Water quality data that were collected during Phase 2 of the USAID-funded Water Resources Program (MEG, 2000), and which were reviewed in PWA's water resources office, suggest that springs in the Nablus area (and the West Bank as a whole) contain elevated concentrations of various metals and detectable concentrations of herbicides (e.g., Fasayel and Al Balad springs).

For purposes of this study, the use of spring water is not considered to significant compared to the scale of infrastructure described herein. However, concurrent VWS institutional programs will address opportunities to optimize use of these springs.

6.2 Water Supply from Palestinian Wells in the Nablus Area

An overview of domestic supply wells in vicinity of Nablus is shown in Table 6-1. Most wells are operated either by Nablus Municipality or Mekorot, but Table 6-1 also includes some private, agricultural wells that periodically sell water to Nablus Municipality.

Decisions on water allocation from Palestinian wells are made by Nablus Municipality, and most of the water is supplied to the town of Nablus. For purposes of this study, it is assumed that existing supply wells are unavailable for the South Nablus villages service area.

It is also assumed that new wells for the South Nablus villages service area will have to be drilled in the Eastern or Northeastern Aquifer Basins. While the Western Aquifer Basin (WAB) is the most productive aquifer basin within the West Bank, it is considered to be inaccessible for Palestinian development and use at this time. Past efforts under the USAID-funded Water Resources Program to obtain well drilling permits from Israeli authorities in the WAB have been unsuccessful. Direct access to the WAB would greatly improve the water supply situation of the South Nablus villages service area (and the West Bank in general).

On the assumption that the WAB cannot be developed for Palestinian use, the only other potential sources of new water would be imported water from the west. Water importation (e.g., desalinated water from the Gaza Strip or other entities) may be an option for the future, but is not considered a feasible option for this study, given the need to satisfy immediate water requirements in the study area.

The Nablus villages service area spans the boundary area between the Eastern and Northeastern Aquifer Basins, however, structural geology, topography, aquifer recharge patterns, and engineering considerations limit the potential for new, large-scale wellfield development within the service area. For example, recent exploration drilling and testing in Aqraba and Turmus Ayyeh have yielded negative results.

One promising new well location has been identified near the village of Rujeib, just a few kilometers to the southeast of Nablus. Rujeib is located hydraulically down gradient and within 6 kilometers of three wells (Huwarah, Audala, and Quza) that combined pump about 23,000 m^3/day from the Lower Cenomanian aquifer.

The well at Rujeib was proposed by the PWA, and has been endorsed by Mekorot. Based solely on data and correlations from the surrounding wells, indications are promising that Rujeib's individual well capacity could exceed 300 m^3/hr, or 6,000 m^3/day (based on 20-hour production cycles). This represents 75 % of the year 2003 requirements of the Nablus villages service area.

However, predictions on long-term production from the planned Rujeib well will ultimately have to be proven through field-testing, and have to be viewed in context of regional-scale aquifer and wellfield management. While indications for high-capacity production are favorable, there is no guarantee that pumping in excess of 300 m^3/hr can be sustained without regional impacts. If pumping proceeds at rates that exceed the wellfield's replenishment capacity or the aquifer's sustainable yield, this may result in significant lowering of regional water tables.

From an operational point of view, 'excessive' drawdown implies that pumps may need to be deepened and/or substituted, that production costs will increase, and that pumping efficiencies and rates may decrease with time. From a management perspective, pumping in excess of the sustainable yield of the aquifer implies that the aquifer system would be mined.

Until the Rujeib well is actually drilled and hydraulically tested, and for purposes of this study, it is assumed that long-term production from the Rujeib well will be limited to 250 m^3/hr, or 5,000 m^3/day (based on 20-hours per day pumping cycles).

At this time, it is recommended that a detailed hydrogeological and water balance study of the Rujeib area be conducted. Future production from the Rujeib well must also be accompanied by careful monitoring of water levels from existing and any new monitoring wells in the area.

This is necessary so that the true aquifer response to pumping can be quantitatively assessed and is considered especially relevant given the down gradient location of Rujeib vis-à-vis the production wells at Quza, Huwara, and Audala.

Monitoring should also include regular/continuous measurements of springs (e.g., Ein Beddan), as pumping from the Rujeib well may potentially impact local springs.

Table 6-1 Overview of domestic water supply in the Nablus and the Nablus villages service area

Well Name	Coord. X	Coord. Y	Elevation (mASL)	Aquifer	Total Depth (m)	Approx. Average Production (m3/day)	Status
Domestic Wells Currently Operated by Nablus Municipality or Privately							
Audala	175800	172800	510.0	Lower	522	6849	In production
Bethan 1	180150	185400	210.9	Upper	745	3288	In production
Bethan 2	182750	185750	90.0	Upper	413	3151	In production
Beit Iba	168900	183000	-30.0	Upper	672	4110	In production
Tubas Water Project	182300	189650	223.0	Turon.	78	457	In production
Abu Khamzaron	182370	188890	175.0	Turon.	80	706	In production
Wadi Al Fara 1	169572	102425	536.0	Lower	750	No Data	In production
Wadi Al Fara 2	170380	103558	552.9	Lower	750	No Data	In production
Deir Sharaf 1	166500	185700	270.0	Upper	300	2078	In production
Deir Sharaf 2A	166750	184750	272.0	Lower	670	3360	In production
Abed Al Kareem Salem	188730	181150	-40.0	Upper	150	363	In production
Domestic Wells Currently Operated by Mekorot in Eastern and Northeastern Aquifer Basins							
Bekaot 1	196510	181040	14.4	Lower	504	1452	In production
Bekaot 2	196900	183300	68.0	Lower	580	4658	In production
Gitit 1	189450	169000	69.6	Lower	706	2192	In production
Gitit 3	191570	173380	19.2	Lower	646	2192	In production
Attara 1	173863	119882	589.8	Lower	793	7534	In production
Attara 2	170873	121893	599.8	Lower	787	5753	In production
Machane Horon (Huwara)	176100	174900	490.0	Lower	585	8219	In production
Tappouh (Quza)	174480	171220	496.9	Lower	548	8219	In production
Argamon 29	169600	115100	738.0	Upper	305	3859 (avg.)	In production
Masua	175780	128520	454.6	Lower	850	No Data	In production

6.3 Beit Dajjan Well – A Potential Source of Water for the Beit Furik and Beit Dajjan Villages

In 1999, an intended production well was drilled under a German-funded program near the village of Beit Dajjan. The well was drilled to a total depth of 648 m below ground level (m BGL), but is blind-cased through the Lower Cenomanian aquifer that historically has been the target for water exploration and production in the West Bank. The well has been completed and installed as an open borehole within the deeper (and older) Tammun and Ein El-Assad Formations.

In relation to the Nablus Villages Feasibility Study, the question has been raised whether or not this well could be used to supply the villages of Beit Furik and Beit Dajjan. Based on the criteria presented in Chapters 3 and 4 and on initial 1997 populations of 2,682 and 7,774 for Beit Dajan and Beit Furik, respectively, the combined total water requirement for these villages is estimated to be 2,046 m3/day in 2003, increasing to 3,769 m3/day in 2023.

A report describing drilling and pump-testing results (GTZ, 1999) concluded that the well is not suitable for production and should only be used for monitoring purposes. This was based on broad interpretations that the water is fossil (more than 5,800 years old) and that the deep aquifers penetrated by the Beit Dajjan borehole do not receive natural recharge.

Based on a review of the GTZ-report, EHP is not satisfied that these conclusions are justified, as presented in the report.

The Beit Dajjan water is undoubtedly old, however, the percent modern carbon (PMC) value of 32 that was obtained from ^{14}C dating is higher than typical values of 10 (or less) obtained for fossil water from the same aquifer in Israel (Geological Survey of Israel, personal communication). The higher value would imply that the water is not entirely fossil, but may be mixed with renewable, atmospheric water.

If the Beit Dajjan well water is a mix of fossil and 'new' water, there is a strong likelihood that the deeper formations (underlying the Qatana Formation) are hydraulically connected to the shallower aquifers that receive direct recharge, notably the Upper and Lower Cenomanian aquifers. Mixing of water can occur naturally in only two ways:

a) Vertical leakage of 'new' water through the Qatana Formation, or
b) Direct hydraulic communication, from regional faulting that juxtaposes the Beit Kahil Formations of the Cenomanian aquifers against the deeper, pre-Qatana formations.

Both are feasible, and the latter option is considered a distinct possibility given the faulted, geological characteristics of the area.

A Mekorot-operated production well, Gitit 3, is located only a few kilometers to the east-southeast of the Beit Dajjan well. Gitit 3 pumps water from both the Lower Cenomanian aquifer and the deeper pre-Qatana formations that are described in the GTZ report. ^{14}C age-dating of water from Gitit 3 has yielded PMC values between 25-30 (Mekorot, pers. comm.), which is similar to the result from Beit Dajjan. Gitit 3 alone produces more than 2,000 m^3/day on average. The Israeli wells Fazael 2 and 9 are also comparable, as they are near the eastern edge of the Eastern Aquifer.

While the hydraulic testing procedures at the Beit Dajjan well were seriously flawed, available test-pumping data provide indications that the production capacity of the well could be in the order of 1,200-1,400 m^3/day, or about 61 to 71% of the year 2003 requirements of the Beit Furik and Beit Dajjan villages.

The most compelling data were collected during a constant-rate test when the well was pumped for a period of 80 hours at an approximate constant rate of 74 m^3/hr. During this test, water levels were slowly stabilizing at a total drawdown of about 19 meters. Specific capacity data would indicate a well with quite favorable hydraulic characteristics. Unfortunately, adequate recovery data were not measured (or presented in the report), and therefore, interpretations on the well's long-term production capacity cannot be conclusively assessed at this time.

Re-testing of the Beit Dajjan well, with a carefully planned and executed hydraulic testing program, should be considered to obtain the data necessary to draw final conclusions about the production capacity of the well. Before such testing is conducted, it is recommended that basic water level monitoring be conducted over the present rainy-season to examine if the water level in the well responds to rainfall events in the region. If the shallow aquifer system is in hydraulic communication with the deeper aquifer system, as described above, then the water level in the Beit Dajjan well would be expected to respond accordingly.

Since no other data exist, and the Beit Dajjan well allows for a first and unique study of the deeper aquifer system, the expected time lag between a rainfall event and a water level response cannot be predicted. It could be on the order of days or months, and therefore requires careful measurement over the entire rainy-season. Measurements should be carried out as frequently as possible, preferably on a daily schedule, certainly on a weekly schedule.

The decision to re-test Beit Dajjan well should be made on the basis of monitoring data analysis.

7 COMPARISON OF OPTIONS AND RECOMMENDATION

7.1 INTRODUCTION

Three alternative pipe routes were compared based on capital cost, ease of implementation, and anticipated operation and maintenance impacts. All costs presented are in year 2001 U.S. dollars. On the basis of these analyses, a recommended design alternative is given. Based on this recommendation, three partial service options are presented for serving either all of the 18 villages, or either of the two clusters.

7.2 CAPITAL COST

7.2.1 Distribution Systems

Capital costs for the distribution system components were developed based upon previous pipeline projects in the West Bank, and on material costs provided by manufacturers for 16 bar high-density polyethylene (HDPE) pipe. Note that while HDPE was used for pre-design cost estimating, other pipe materials will be reviewed during design, in consultation with PWA. Unit costs for installed pipes, including associated fittings, reducers, and isolation valves, are listed in **Table 7-1**. All costs include 15 percent for contractor general conditions, overhead and profit. Pressure reducing valves, air release valves, and clean-outs were assumed to constitute an additional 15 percent, beyond the cost of the distributions system piping.

Table 7-1
Unit Costs for Installed 16 Bar HDPE Pipe in Rural West Bank

Nominal Pipe Diameter (mm)	Material Unit Costs (US$/meter)	Installation Unit Costs (US$/meter)	Total Installed Unit Cost (US$/meter)
19	3	7	10
25	4	9	13
50	8	14	22
75	18	26	43
100	25	26	50
150	45	32	77
200	62	32	94
250	112	40	152
300	139	40	179
350	217	49	266

7.2.2 Transmission Pipelines

Similar to the distribution system pipework, transmission pipeline costs were determined based on previous projects in the West Bank and on material costs provided by manufacturers for concrete lined steel pipe. Unit costs for installed pipes, including associated fittings, reducers, and isolation valves, are listed in **Table 7-2**. As with the distribution pipework, all costs include 15 percent general conditions, overhead and profit.

Table 7-2
Unit Costs for Installed Concrete Lined Steel Pipe in Rural West Bank

Nominal Pipe Diameter (mm)	Material Unit Costs (US$/meter)	Installation Unit Costs (US$/meter)	Total Installed Unit Cost (US$/meter)
100	40	30	70
150	46	34	80
200	56	34	90
250	70	45	115
300	78	47	125
350	93	57	150
400	109	71	180
450	167	93	260

7.2.3 Storage, Pumping, and Disinfection

Costs for storage, pumping, and disinfection facilities were based on unit costs and cost formulas derived from previous project in the West Bank and from information provided by product manufacturers and vendors. All costs are assumed to include contractor general conditions, overhead, and profit. The following assumptions were made regarding capital costs:

1) **Well Pumps**. Supply and installation of well pumps and related facilities assumes a base cost of $200,000 plus an additional $200,000 per ($m^3$/hr x m head) / 200,000. For example, for a pumping condition of 500 m^3/hr at 400 m head, the pump costs would be: [$200,000 + $200,000 x (500 x 400 / 200,000)] = $400,000. It should be noted that these costs do not include initial site acquisition, drilling, casing or testing of the well.

2) **Generators and Ancillaries**. Supply and installation of generators and ancillaries assumes a base cost of $100,000 plus an additional $75,000 per (kW) / 500. For example, generators and ancillaries at 500 kW would cost: [$100,000 + $75,000 x (500 / 500)] = $175,000.

3) **Booster Pump Stations**. Supply and installation of booster pumps assumes a base cost of $75,000 plus an additional $75,000 per ($m^3$/hr x m head) / 200,000. For example, for a pumping condition of 125 m^3/hr at 180 m head, the pump costs would be [$75,000 + $75,000 x (125 x 180 / 200,000) = $83,000.

4) **Disinfection and Ammoniation Facilities**. Supply and installation of liquid sodium hypochlorite storage and feed facilities assumes a base cost of $40,000 plus an additional $100 per liter per day (lpd) capacity. For an approximate dose of 8 parts per million (ppm) of sodium hypochlorite, this requires a 400 lpd system ($40,000 + $100 x 400lpd = $80,000). Anhydrous ammonia storage and feed facilities assume a base cost of $30,000 plus an additional $3,000 per kg/d capacity. For an approximate dose of 0.8 ppm of ammonia, this requires a 4 kg/d system ($30,000 + $3000 x 4kg/d = $42,000). The total cost is rounded to $120,000 as presented in the cost tables. Finally, note that these estimations are only valid for a capacity range of 100-1000 lpd hypochlorite and for 2-10 kg/day for ammonia.

5) **Storage Reservoirs.** Costs for construction of regional and local ground storage reservoirs, for the range of 750 to 10,000 m^3, were based on the following cost formula:
   i. Cost = 100,000 + 250 x $(\text{Capacity})^{0.88}$
   ii. Where cost is in US$ and capacity is in cubic meters.

7.2.4 Summary of Capital Costs

A summary of the total estimated capital costs for the three design alternatives is presented in

Table 7-3. Costs do not include engineering services during design or construction. A 20 percent contingency has been added to the planning level estimate to account for unanticipated conditions, which may arise during the design or during construction.

TABLE 7-3
CAPITAL COST BREAKDOWN OF ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 3
Well Development	575,000	575,000	575,000
Disinfection	120,000	120,000	120,000
Transmission Pipelines	8,873,000	9,352,000	8,179,000
Booster Pump Stations	582,000	582,000	582,000
Reservoirs	2,660,000	2,960,000	2,790,000
Distribution Systems	9,600,000	9,600,000	9,600,000
Subtotal	22,410,000	23,189,000	21,846,000
Contingency (20%)	4,482,000	4,637,800	4,369,200
Total Capital Cost	**$26,892,000**	**$27,826,800**	**$26,215,200**

7.3 Operations and Maintenance (O&M) Costs

Annual running costs can be divided into three categories: direct operating expenses, maintenance and replacement costs, and administrative and financial costs. Each of these cost categories is discussed briefly below.

Direct Operating Expenses
The following assumptions were made regarding the calculation of operating expenses:

1) **Water Use**. Water is used at a constant per capita rate throughout the life of the project.

2) **Pumps.** Pumps and motors are assumed to have a combined efficiency of 75% with pumps operating 20 hours per day on average.

3) **Electricity**. The unit rate of electricity was estimated at $0.09/kwh (US).

4) **Generator Use**. Generators are assumed to operate for 1 hour per day at twice the running costs of the normal electricity supply.

Maintenance and Replacement
Standard maintenance and replacement costs are calculated as a percentage of the investment costs of the different components of the system. The annual rates used in this study are presented in **Table 7-4.**

Table 7-4
Annual Maintenance and Replacement Costs as Percentage of Capital Costs

Facility Component	Annual O&M Rate*	Alternative 1	Alternative 2	Alternative 3
Transmission Lines	2%	$ 213,000	$ 224,000	$ 196,000
Distribution Network	4%	$ 461,000	$ 461,000	$ 461,000
Reservoirs	1%	$ 32,000	$ 36,000	$ 33,000
Disinfection System	5%	$ 7,000	$ 7,000	$ 7,000
Pumping Stations	7%	$ 49,000	$ 49,000	$ 49,000

*Percentage Rate applied on capital cost including 20% contingency from Table 7-3

Administrative and Financial
Administrative and financial costs are more difficult to quantify, and will be a function of the established utility structure governing the 18 villages. It is critical that well-trained regional and local staff operate the water systems in order to provide high quality service to the customers. The constituency and responsibilities for Joint Services Councils (JSC) and Project Implementation Units (PIU) in the villages will be evaluated and recommended within concurrent institutional programs under the VWS. Annual administrative and financial costs have therefore not been included within the cost estimates of this feasibility study.

O&M Cost Summary
A breakdown of the annual O&M costs estimated for the three alternatives is presented in **Table 7-5**.

Table 7-5
Annual O&M Costs in US$ based on Percentage of Investments

Category	Alternative 1	Alternative 2	Alternative 3
Maintenance and Replacement	634,800	647,400	622,200
Electricity	450,900	450,900	450,900
Diesel Fuel	45,000	45,000	45,000
Chemicals	65,600	65,600	65,600
Total Annual Costs	**$ 1,196,300**	**$ 1,208,900**	**$ 1,183,700**
Unit Costs ($/m^3)	$ 0.66	$ 0.66	$ 0.65

7.4 DISCUSSION AND RECOMMENDATIONS

7.4.1 Costs and Ease of Operation
In terms of capital cost, Alternative 3 is the least expensive of the three alternatives, due primarily to a significantly smaller total length of transmission piping (66.8 km, compared to 72.0 and 77.6 km for Alternatives 1 & 2, respectively). In addition to the capital cost savings, Alternative 3 is advantageous in that it locates the major pipeline feeding the Aqraba cluster on a dirt road, minimizing traffic impacts and permitting constraints during construction (see Appendix A for complete description of pipe routing). Alternative 3 includes more reservoirs than Alternative 1, but fewer then Alternative 2, and it locates the Aqraba area booster pump station at a location where high power lines are available to run the pumps, alleviating the need to operate the pumps with a generator.

Operations and maintenance costs for all three alternatives would be roughly equivalent, and is not a factor in the selection.

7.4.2 Relative Environmental Impacts
Construction: Alternatives 1, 2 and 3 all have similar types of environmental impacts due to construction, the major difference being that under Alternative 3, these impacts are slightly reduced, due to shorter lengths of transmission piping.

Noise during construction is inevitable and this can be addressed by limiting the contractor working hours to the daytime. This would, however, have two disadvantages:

- Increased time to implement the contract and deliver much-needed water supply to the villages.
- Congestion due to traffic disruption, accentuated in and around the villages during daylight hours.

Operation of the Supply Network: Noise from operation of the pumping stations is inevitable. The Rujeib well site will likely be sited away from the communities. The number of booster stations has been minimized in all three alternatives; with both pump stations located in areas where electrical power is available, preventing the need for diesel generators on a daily basis. Diesel generators will be provided for emergency power at each pumping station.

Availability of Water Supply and Drainage/Sanitation: The environmental impacts due to the availability of a water supply to the 18 villages will be discussed in detail in the Environmental Assessment Report written in conjunction with the detailed design for the facilities.

7.4.3 Recommendation

For the above reasons, and based upon discussions and recommendations from the Palestinian Water Authority (PWA), Alternative 3 is the recommended approach for providing water to the South Nablus area. The total capital cost for this alternative is $26.2 million (US), with an annual O&M cost of $1.2 million, excluding administrative and financial costs.

7.5 Modified Level of Service Options

The overall level of service provided by the recommended alternative, as discussed in Sections 4 and 6, is less than the minimum design criteria, due to the limited supply of water from the Rujeib well. The PWA has expressed their desire to provide a minimum level of service to as many villages as possible, rather than providing the designated 150 l/c/d to a limited number of villages. Whether or not such an approach is followed will depend on the available funds to construct water systems in the 18 villages. This will be discussed with PWA and USAID further during design. To aid in the allocation of funding for these projects, three level of service options have been defined as presented in **Table 7-6** below, with relative cost breakdowns as presented in **Table 7-7**.

TABLE 7-6
LEVEL OF SERVICE OPTIONS

	Population Served		Level Of Service (l/c/d)		Capital Cost	Per capita Cost (2003)
	2003	2023	2003	2023		
Option 1: All Villages	53,248	98,091	94	51	$26,215,200	$492
Option 2: Burin Cluster + Awarta	28,522	52,543	175	95	$13,729,200	$481
Option 3: Aqraba Cluster + Rujeib	34,083	62,786	147	80	$18,056,400	$530

TABLE 7-7
CAPITAL COSTS FOR LEVEL OF SERVICE OPTIONS

	Option 1 (All Villages)	**Option 2 (Burin Cluster)**	**Option 3 (Aqraba Cluster)**
Well Development	575,000	575,000	575,000
Disinfection	120,000	120,000	120,000
Transmission Pipelines	8,179,000	3,849,000	5,570,000
Booster Pump Stations	582,000	237,000	582,000
Reservoirs	2,790,000	1,470,000	2,100,000
Distribution Systems	9,600,000	5,190,000	6,100,000
Subtotal	21,846,000	11,441,000	15,047,000
Contingency (20%)	4,369,200	2,288,200	3,009,400
Total Capital Cost	**$26,215,200**	**$13,729,200**	**$18,056,400**

It should be noted that no recommendations have been made in this report regarding which of the level of service options to pursue. From an engineering standpoint, any of the three options would be considered feasible. However, service will need to be provided based on available funding at the time the projects are awarded. It would also be possible to begin initial construction based on either Option 2 or 3, providing service to the remaining villages at a later date, depending again on the available funds.

High priority should be given to supplying water to all of the villages, as the existing sources of supply do not provide safe or reliable water to any of the study area villages. Finally, it should be noted that an institutional assessment is being carried out concurrent with this effort evaluating, among other things, health related practices related to current water supplies in the study area villages.

ANNEX A

DESCRIPTION OF ALTERNATIVE TRANSMISSION PIPELINE ROUTING

ALTERNATIVES 1 - 3

Description of Alternatives Transmission Pipeline Routing

There are many alternatives for laying the routes of the main conveyance pipelines for Nablus villages project. The factors that should be considered in selecting the feasible alternative are the cost of construction, the land acquisition, ease of construction, licensing requirements and the environmental concerns.

The layout for the three different alternatives are shown in Section 5. The following is the description for the segments of the components for these alternatives. The three alternative routes and the corresponding junctions (J) and tanks (T) are shown in Figure A-1.

Alternative 1

Burin Cluster:

Segment T1 – J5: The road is a major road with heavy traffic. It is asphalted road of flat terrain. It is possible to install the pipeline at one shoulder of the road to avoid traffic disruption.

Segment J5 – J6: It is a deteriorated asphalt road with medium traffic load. The terrain is smooth with scattered houses and olive trees plantation on both sides. It is possible to install the pipelines at one side of the shoulders for the first half of the segment and within the road for the second half.

Segment J6 – J8: This is a local road of compacted basecourse. It has a steep terrain particularly inside Burin village, but the terrain becomes moderate after Burin. Its width ranges from 4 to 10m. It is recommended to install the pipeline at the stable side (i.e., not filled side). The segment has some sharp horizontal curves.

Segment J8 – J10: This is a narrow asphalted road of good condition. It has horizontal curves and the terrain is moderate to steep. There are olive farms on both sides of the road. The pipeline might be installed in either the two shoulders.

Segment J10 – J54: It is a compacted basecourse road with flat terrain and easy for construction. Olive and fig farms are located on both sides of the road. The traffic is low at this segment. It is possible to locate the pipeline at one side of the road.

Segment J6 – J15: This road is a local one with low traffic load. It is a narrow and deteriorated asphalt road with sharp horizontal curves in some places.

Segment J15 – J18: This segment is a dirt road (which is also called a quarry road). The traffic is light and it is a narrow road. The work on this road will be easy as it is an opened area. The terrain is moderate and there are some horizontal curves.

Segment J18 – J66: It is a narrow deteriorated asphalt road. There are horizontal curves and the terrain is moderate slope.

Aqraba Cluster

Segment J4 – J22: It is an asphalted narrow road with scattered houses on both sides. The traffic is light. The terrain is level. It is possible to locate the pipeline on one shoulder of the road.

Segment J22 – J27: This is a narrow deteriorated asphalt road with light traffic. The construction is easy due to the fact that the area is opened. There are many sharp horizontal curves. It is possible to locate the pipeline at one shoulder of the road.

Segment J27 – T8: The road is a steep with sharp horizontal curves. It's first half is a deteriorated asphalt and the second half is a dirt road. The houses are located on both sides of the road at the beginning and then it becomes an opened area.

Segment J27 – J28: It is a narrow road with steep terrain. The surface of the road is covered by basecourse. The traffic is light.

Segment J27 – J30: The road is narrow with deteriorated asphalt for the first third and dirt road for the remaining part. The terrain is moderate. There are olive farms on both sides of the road. The traffic is light. The area is opened and easy to work.

Segment J30 – Duma: The road is narrow (about 4m wide) with steep to moderate terrain. There are several horizontal curves. The surface is covered with compacted basecourse. It is an easy area for working.

Segment J30 – J60: It is a narrow deteriorated asphalt road. The traffic is light.

Segment J60 – J43: This is an asphalt road of good condition. The traffic is low. It is possible to locate the pipeline at one shoulder of the road.

Segment J43 – J61: This is narrow deteriorated asphalt road. There are few horizontal curves and the terrain is steep. The traffic is light.

Segment J43 – J47: It is a dirt road with level terrain. The traffic is light. Work will be easy as the area is opened.

Segment J47 – J65: It is local narrow road. It is an asphalted road with moderate condition. The traffic is light and the terrain is level. There are scattered houses around both sides of the road particularly at its end.

Segment J47 – J64: It is local narrow road with light traffic. The surface of the road is asphalted with good condition. The terrain is steep. There are some horizontal curves. There is enough space on both sides of the road to locate the pipeline.

<u>Alternative 2</u>

<u>Burin Cluster</u>

The route will be similar to that of Alternative 1 except that feeding Einabus village will be done through Aqraba cluster pipeline.
Segment J50 – J66: It is a deteriorated asphalt road of width 6-8m. The traffic is moderate. The terrain is level. Most of the road is surrounded by houses on both sides. It is possible to locate the pipeline at one shoulder of the road except in the places where the road becomes narrow and there are no shoulders.

<u>Aqraba Cluster</u>

Segment J4 – J50: This is major asphalted road with heavy traffic. The terrain is level. It is possible to locate the pipeline at one shoulder of the road or within the right of way. There will be disruption to the normal life of the residents of Huwwara town during construction.

Segment J50 – J22: The road condition is similar to that of segment J4 – J50 except that the terrain will be relatively moderate and there are few horizontal curves.

Segment J22 – J60: It is a main road with heavy traffic. The road is asphalted and it is in good condition. It is possible to locate the pipeline at one shoulder of the road. The terrain is level at the start of this segment and then it becomes steep. There are few horizontal curves. It might be difficult to get licensing for this segment as it is a main road.

Segment J19 – J20: It is narrow asphalt road with good condition. The traffic is light. The terrain is level. It is possible to locate the pipeline within the right of way of the road.

The other segments of this alternative are similar to those of Alternative 1.

Alternative 3

Burin Cluster

The route is similar to that of Alternative 1.

Aqraba Cluster

The segments are similar to those of Alternative 1 except of the following segments:

Segment J22 – Beita Al-Fouqa: It is a narrow dirt road. The terrain is steep with few horizontal curves. The traffic is light. It is an opened area. There are olive farms on both sides of the road.

Segment Beita Al-Fouqa – J26: It is a road with its surface covered by basecourse. The width of the road is about 6m. The terrain of the road is moderate. The traffic is light. There is enough space to work in this road.

Segment J23 – J24: It is a dirt road with moderate to steep terrain. There are few sharp horizontal curves. The traffic is light. There is enough space to work within this road (i.e., easy for construction).

Figure A-1 The Junctions and Tanks of the Alternative Transmission Routes

ANNEX B

PRELIMINARY HEADLOSS CALCULATIONS AND OUTPUT DATA FROM H2ONET HYDRAULIC MODELING SOFTWARE

ALTERNATIVES 1 - 3

ANNEX C

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Wastewater Existing Situation at South Nablus Villages

Community	Population	Households	Existing Network for Black Wastewater: Yes	Existing Network for Black Wastewater: No: Septic Tank	Existing Network for Black Wastewater: No: Cesspit	Existing Network for Black Wastewater: No: Surface Channels	Existing Network for Black Wastewater: No: In the Streets	Average Capacity of the Septic and Cesspit m^3	Frequency of Emptying No./Year	Separation of Grey Wastewater from Black Wastewater: All Houses	Separation of Grey Wastewater from Black Wastewater: Some Houses	Separation of Grey Wastewater from Black Wastewater: No	Grey Waste Water is used for: Irrigation of Gardens	Grey Waste Water is used for: Irrigation of Crops	Grey Waste Water is used for: Throwing to the Streets	Ownership of Tankers: Private: From the Village	Ownership of Tankers: Private: From Outside the Village	Ownership of Tankers: Local Council
Burin Cluster																		
Asira Al Qibliya	2,015	284			x			5	6		x				x		x	
Awarta	5,123	720																
Burin	2,897	361		x	x				12		x				x		x	
Einabus	1,957	290			x			20	2		x				x		x	
Iraq Burin	679	99																
Madama	1,462	219			x			27			x				x		x	
Rujeib	3,452	491																
Sarra	2,549	334	30%		70%			27	3		x		x				x	
Tell	4,179	587		x	x			17	2			x				x		
Urif	2,503	369			x			40	12		x		x			x		
Aqraba Cluster																		
Aqraba	6,991	987		x	x			10	4		x		x			x		
Duma	1,957	239																

Wastewater Existing Situation at South Nablus Villages

Community	Population	Households	Existing Network for Black Wastewater						Average Capacity of the Septic and Cesspit m^3	Frequency of Emptying No./Year	Separation of Grey Wastewater from Black Wastewater			Grey Waste Water is used for			Ownership of Tankers		
			Yes	No							All Houses	Some Houses	No	Irrigation of Gardens	Irrigation of Crops	Throwing to the Streets	Private		Local Council
				Septic Tank	Cesspit	Surface Channels	In the Streets										From the Village	From Outside the Village	
Jalud	399	58																	
Jurish	1,219	144		x	x				20	12		x		x				x	
Majdal Bani Fadel	1,926	276		x	x				16	12		x		x	x			x	
Osarin	1,437	223			x				15	2		x						x	
Qaryut	2,177	287																	
Qusra	3,916	473																	
Talfit	2,637	330			x				15	2			x					x	
Yanun	133	19			x								x					x	

Wastewater Existing Situation at South Nablus Villages

Community	Cost of each fill of Tanker (NIS)	Cesspits under the Streets		Emptying the Cesspits into the streets in Winter		Tankers discharge the fill in	Name of the Wadi	Agricultural Land in Dunum	Black Wastewater used for Crops			Authorities or NGO's involvement to solve black wastewater problem		Studies done for Sanitary Projects		No Sanitary Network be		
									No	Yes		No	Yes, Activity description	No	Yes,Study name	No Studies	No Funds	No Permits from Israel
		Yes	No	Yes	No					Crops	Area							
Burin Cluster																		
Asira Al Qibliya	40		x		x	Road sides			x			x				x	x	
Awarta																		
Burin	80	x			x	Adjacent wadi		18000	x			x		x		x	x	
Einabus	120	x			x	Adjacent wadi	Wadi at Teen	3500	x			x		x		x	x	
Iraq Burin																		
Madama	40	x		x		Adjacent wadi	Wadi al-Khalayel Al-wad Al-Garbi	3500	x			x		x		x	x	
Rujeib																		
Sarra	20	x		x		Adjacent wadi	Wadi Ash-Sharq al-Wad Al-Garbi		x			x	PHG	x		x	x	
Tell		x			x	Adjacent wadi	Al-Wadi Al-Garbi		x			x		x		x	x	
Urif	60	x			x	Adjacent wadi	Wadi as Sarar Wadi as Sahel	15000	x				PHG & SC built some SDT's	x			x	
Aqraba Cluster																		

Wastewater Existing Situation at South Nablus Villages

Community	Cost of each fill of Tanker (NIS)	Cesspits under the Streets		Emptying the Cesspits into the streets in Winter		Tankers discharge the fill in	Name of the Wadi	Agricultural Land in Dunum	Black Wastewater used for Crops			Authorities or NGO's involvement to solve black wastewater problem		Studies done for Sanitary Projects		No Sanitary Network bec		
									No	Yes		No	Yes, Activity description	No	Yes,Study name	No Studies	No Funds	No Permits from Israel
		Yes	No	Yes	No					Crops	Area							
Aqraba	50	x			x	Adjacent wadi		144000	x			x		x		x	x	x
Duma																		
Jalud																		
Jurish	100		x		x	Adjacent wadi	Wadi Al-Masri	4000	x			x		x		x	x	
Majdal Bani Fadel	50		x		x	Adjacent wadi & Agrliculutral land			x				Building Septic Tanks	x			x	
Osarin	50		x		x	Agricultural land			x			x		x				
Qaryut																		
Qusra																		
Talfit	40		x		x	Adjacent wadi & Road sides	Wadi Talfit		x			x		x		x	x	
Yanun	60		x		x	Adjacent wadi Road sides Agricultural lands	Wadi Al-Khirba	5000	x			x		x		x	x	

cause of
Not Capable to manage the Network

cause of
Not Capable to manage the Network
x

Wastewater Existing Situation at South Nablus Villages

Community	Current Projects for Sanitary Sector			Applications for new Projects			Cooperation Willingness with JSC for Sanitary Project			Willingness of Local Council Involvement in Sanitary Projects			Willingness of Community Involvement in Sanitary Projects			People main Occupations are in				Living Standard of the Community			Remarks
	No	Yes		No	Yes		Yes	Not Sure	No, Explain	Yes	Not Sure	No	Yes	Not Sure	No	Agriculture	Local Workers	Inside Israel	Independent Projects	High	Medium	Low	
		Name	Funding Authority		Project	Applied to																	
Burin Cluster																							
Asira Al Qibliya	x			x				x		x			x				x	x			x		
Awarta																							
Burin	x			x			x			x			x			x		x	x		x		
Einabus	x			x			x			x			x			x	x	x	x		x		Cesspit polluting the underground water as well as the odour.
Iraq Burin																							
Madama	x			x			x			x			x			x	x	x	x		x		Many diseases have been recorded especially Ameba, too many insects, many social problems due to the septage to the adjacent houses.
Rujeib																							
Sarra	x			x				x		x			x			x		x			x		The current project is very limited, and not planned well, as people start to connect to the existing line without coordination with any technical body.
Tell	x			x			x			x			x		x	x			x		x		Pollution of the agricultural lands from the discharge of tankers, septage to the streets as well as pollution of the underground water and cisterns.
Urif	x			x			x			x			x			x	x	x	x		x		The village is on top of a hill which makes it easier to flow by gravity to two wadis in the north & south directions. Also it is accessible to build WWTP between the two wadis.
Aqraba Cluster																							
Aqraba	x				Projects priorities form	MoLG	x			x			x			x	x	x	x		x		The commercial part in the center of the village is in bad need for sewage, there is no place for septic tanks, also high cost of construction up to 5000 NIBS each.
Duma																							

Wastewater Existing Situation at South Nablus Villages

Community	Current Projects for Sanitary Sector			Applications for new Projects			Cooperation Willingness with JSC for Sanitary Project			Willingness of Local Council Involvement in Sanitary Projects			Willingness of Community Involvement in Sanitary Projects			People main Occupations are in				Living Standard of the Community			Remarks
	No	Yes		No	Yes		Yes	Not Sure	No, Explain	Yes	Not Sure	No	Yes	Not Sure	No	Agriculture	Local Workers	Inside Israel	Independent Projects	High	Medium	Low	
		Name	Funding Authority		Project	Applied to																	
Jalud																							
Jurish	x			x			x			x			x			x			x		x		
Majdal Bani Fadel	x			x			x			x			x			x					x		
Osarin	x			x			x			x			x					x				x	
Qaryut																							
Qusra																							
Talfit	x			x			x			x			x			x	x	x	x		x		Sanitation project is very important since the cesspits is strongly polluting the underground water specially the springs.
Yanun	x			x					The village is isolated, in addition to the geographical location makes it impossible to join the adjacent villages.	x			x			x		x	x			x	Sanitation project is very important, because many cesspits are on top of the hill which pollute the spring under the hill.